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Associations of Environmental Factors and Prevalence of Vitamin D Deficiency in Iran

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ABSTRACT

Introduction: Vitamin D deficiency is a major health problem, which is unexpectedly prevalent in Iran. The ultraviolet (UV) rays of the sun are considered to be the foremost source of vitamin D in humans. In contrast, several environmental factors could decrease UV transmission to the earth, thereby reducing vitamin D absorption. Considering that the key role of environmental factors in vitamin deficiency has been neglected, the present study aimed to investigate the associations between environmental factors (e.g., geographical and air pollution parameters) with the prevalence of vitamin D deficiency in Iran.
Methods: The duration of the prevalence of vitamin D deficiency were extracted from the previous studies conducted in different cities in Iran, where vitamin D deficiency was reported. Afterwards, the environmental factors that were reported to affect sunlight transmission through the atmosphere were collected based on the place and time of vitamin D deficiency as mentioned in the reviewed studies via different geographic databases. The associations between the environmental factors and prevalence of vitamin D deficiency were determined. In total, 35 studies were reviewed completely.
Results: The results indicated significant correlations between the prevalence of vitamin D deficiency and some environmental factors (e.g., cloudy and clear days). However, no significant association was observed between vitamin D deficiency and other environmental factors, such as geographical parameters (e.g., sunshine, longitude, latitude, elevation, humidity, and temperature) and air pollution (e.g., number of days with dust and visibility of ≤2 km).
Conclusion: According to the results, there were significant associations between the prevalence of vitamin D deficiency and environmental factors, such as cloudy and clear days. Therefore, adequate exposure to sunlight for the absorption of vitamin D is strongly recommended.

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Introduction

Vitamin D is a steroid hormone that plays a key role in the metabolism of minerals, especially calcium and phosphorus (1). Vitamin D enhances the absorption of phosphorus and calcium from the intestines and reduces the excretion of these minerals from the kidneys, thereby improving the osteoporosis process (2). Several studies have emphasized on the role of vitamin D in the prevention of heart diseases, inflammatory bowel disease, multiple sclerosis, rheumatoid arthritis, type I diabetes, immune system diseases, and infections (2).

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In humans, ultraviolet sunlight (280-315 nm) is considered to be the main source of vitamin D, which is composed of 7-dehydrocholesterol in the human skin. Low levels of vitamin D are also supplied by food sources (e.g., fish, eggs, and fortified foods) (3). Since the ultraviolet (UV) rays of the sun are the most important source of vitamin D in humans, factors such as avoiding exposure to sunlight, season, time of the day (absorption peak: 10 AM-3 PM), air pollution, use of sunscreens, living in high latitudes, skin pigmentation, and inadequate consumption of vitamin D could deteriorate vitamin D deficiency in communities. Vitamin D deficiency leads to delayed growth and skeletal development in children, leading to bone softness, muscle weakness, increased risk of fracture, and acute osteoporosis in adults (4).

Previous research has indicated that vitamin D deficiency is a common, severe health issue across the world. According to a study conducted in 2008, vitamin D deficiency was reported to be a pandemic problem throughout the world (5). Other studies in this regard have also indicated that approximately one billion individuals have vitamin D deficiency in various regions in the world (6). Some studies have also demonstrated that 30-50% of the children and adults in the United States, Canada, Europe, Australia, and New Zealand have vitamin D deficiency (7).

Vitamin D deficiency is considered to be a major health issue, which is unexpectedly prevalent in Iran, as well as other countries, such as Turkey, Saudi Arabia, and Kuwait (1). Comparison of the mean prevalence of vitamin D deficiency in Iran in 2000 and 2011 indicated that the rate of vitamin D deficiency is on the rise in Iranian men and women (2). According to a study performed in Isfahan (Iran) in 2011, the prevalence of vitamin D deficiency was 50.8% in adults (7). In addition, vitamin D deficiency has been reported in different years in the other cities in Iran, such as Tehran, Yazd, Urmia, Shiraz, Arak, Zahedan, and Shahrud (2).

Limited studies have investigated the effects of environmental factors on the prevalence of vitamin D deficiency in Iran and other countries. Considering the lack of such studies in developed countries (United States and European countries), it is possible to justify that the food stores of these countries are rich in vitamin D. In the United States and Europe, food products such as milk, yogurt, cheese, some fruit juices, and bread are enriched with vitamin D (8). However, there is the lack of food fortification in developing countries, such as Iran. From a geographical perspective, exposure to sunshine is crucial in the synthesis of vitamin D, while this has been reported to be among the other causes of the high prevalence of vitamin D deficiency in sunny countries such as Iran. This issue requires extensive investigation and could be attributed to various causes, including the type of clothing, vitamin D deficiency in food products (i.e., lack of fortification), hyper pigmentation, lifestyle, and environmental factors (e.g., air pollution) (8). Air pollution is among the major obstacles to proper vitamin D absorption since it prevents the ultraviolet radiation from reaching the earth. Epidemiological data of the individuals living in various geographical latitudes suggest that air pollution, especially ozone troposphere, plays a pivotal and independent role in the spread of vitamin D deficiency (9).

Limited studies have been carried out to determine the role of air pollution in the prevalence of vitamin D deficiency. A research was conducted in Isfahan (Iran) in 2012 in order to investigate the independent effect of air pollution on the prevalence of vitamin D deficiency in children. The obtained results showed an inverse correlation between the air quality index and serum levels of 25 hydroxy vitamin D (25[OH] D), indicating the significant effect of air pollution on vitamin D deficiency in the children living in urban areas (9). Similar studies in other countries, such as France and India, have also demonstrated the key role of air pollution in vitamin D deficiency (10, 11). Most of the studies investigating vitamin D deficiency have reported an association between this condition and its nutritional intake, while the effects of environmental factors (e.g., geographical parameters and air pollution) have been overlooked.

The present study aimed to investigate the associations of environmental factors, such as geographical parameters and air pollution, with the prevalence of vitamin D deficiency in Iran.

Material and methods

In this study, we reviewed all the published studies in Persian and English regarding the prevalence of vitamin D deficiency in different years in Iran. The years of the prevalence of vitamin D deficiency were extracted from the studies in various cities in Iran where vitamin D deficiency was reported. Afterwards, data were collected on environmental factors, such as geographical and air pollution parameters affecting the sunlight transmission through the atmosphere, based on the time and place of vitamin D deficiency as mentioned in the reviewed studies in geographic databases. Finally, the associations between environmental factors and the prevalence of vitamin D deficiency were determined.

Search Strategy and Keywords

The main literature search was conducted via online national and international databases in order to retrieve the studies focusing on vitamin D deficiency. The national databases included Magiran and the Scientific Information Database (SID), and the international databases included Google Scholar, ScienceDirect, Scopus, and PubMed. The literature search was carried out using various keywords, such as vitamin D, prevalence, and Iran.

Selection of the Studies

To ensure the review of the most relevant studies, the inclusion criteria of the study were determined, as follows: relevance to the research objectives, non-duplicate studies in various databases, use of the ELISA method only for measuring the level of 25(OH) D, and considering the serum level of 25(OH) D as the optimal indicator for determining the status of vitamin D. Vitamin D has a half-life of approximately 2-3 weeks in the blood (12). Many researchers have considered a cutoff point of less than 20 and 25 ng/ml for 25(OH) D as an indicator of vitamin D deficiency. Considering the standards, the cutoff point of 25 ng/ml was considered for 25(OH) D as the main index for the inclusion of the collected studies (4).

Quality Assessment and Data Extraction

Data Collection for Vitamin D Deficiency

In total, 1,000 studies were found in the initial literature search, 850 of which were excluded after reviewing the titles and removing the duplicates. Out of the remaining 150 articles, 115 studies were eliminated based on the inclusion criteria of the study. Finally, 35 studies were selected and reviewed completely in order to determine the years and regions relating to the reported prevalence of vitamin D deficiency (Figure 1). Afterwards, environmental parameters were collected for the regions and years mentioned in the reviewed studies.

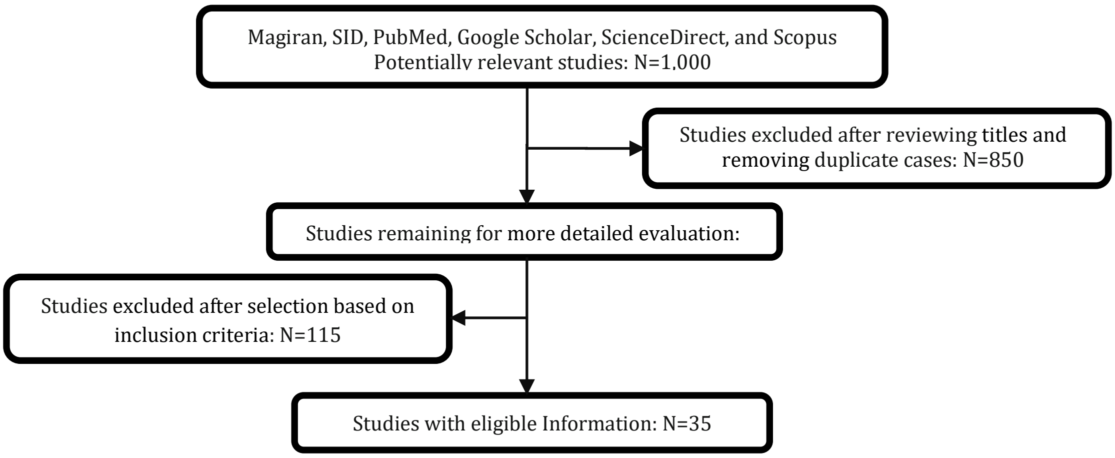

Figure 1. Flow Chart of Article Selection Process

Data Collection for Environmental Factors

The environmental factors collected from the geographic databases included geographical and air pollution parameters. The geographical parameters included the number of clear, cloudy, and partly cloudy days, duration of sunshine (hour), latitude, longitude, elevation, humidity, and temperature. The pollution parameters included the number of days with dust and days with visibility of less than or equal to two kilometers.

The search terms were carried out via online national and international geographical databases to collect the data on the environmental factors. The national geographical databases included the Chahar Mahal and Bakhtiari online geographical database and the online Iran Climatology and Meteorology database. The international geographical databases were the online National Oceanic and Atmospheric Administration (NOAA) database and online Ogimet Weather Service Database (Table 1).

Table 1. Geographic Databases

Uniform Resource Locator (URL)	Databases
http://www.chaharmahalmet.ir/iranarchive.a1sp	Chahar Mahal and Bakhtiari Meteorology
http://climatology.ir/	Iran Climatology
http://www.irimo.ir/far/wd/720-	Iran Meteorology
https://www7.ncdc.noaa.gov/CDO/cdoselect.cmd?datasetabbv	NOAA
http://www.ogimet.com/resynops.phtml.en	Ogimet

Statistical Analysis

Data analysis was performed in SPSS version 16 using correlation tests to examine the associations between the environmental factors and vitamin D deficiency. All the statistical tests were carried out with 95% confidence interval and alpha coefficient of 0.05, and P-value of less than 0.05 was considered significant.

Results

The status of vitamin D deficiency was reviewed in several studies conducted in various regions in Iran. Table 2 shows the year of the studies, age and gender of the patients, type of the studied populations, and prevalence of vitamin D deficiency in different cities in Iran.

Table 2. Studies on Vitamin D Deficiency in Iran

City	Author	Year	Participants (N)	Gender	Age	Prevalence (%)
Yazd	M. Shakiba (1)	2007-2008	Hospital Staff (82)	Male and Female	37	76.9
Isfahan	M. Moussavi (13)	2004	Students (318)	Male and Female	16	46.2
	M. Salek (3)	2004-2006	Children (513)	Male and Female	5	3
	S. Hovsepian (7)	2009-2010	Healthy Adults (1,111)	Male and Female	41	50.8
	A. Zandifar (14)	2011	Migraine Patients (215)	Male and Female	33	45.7 (migraine patients) and 51.8 (control)
	R. Kelishadi (9)	2011-2012	Children (100)	Male and Female	7	37.9
Urmia	S. Gheibi (15)	2012-2013	Children and Adolescents (800)	Male and Female	-	75
Bukan	M. Rafra (16)	2011-2012	High school Students (216)	Female	16	96
Bushehr	K. Moradzadeh (17)	2001	Healthy Adults (5,329)	Male and Female	42	28.5
	Z. Rahnavard (18)	2004-2005	Healthy Men (496)	Male	47	15
	G. Hatami (19)	2011-2012	Asthmatic Children (200) And Healthy Controls (200)	Male and Female	5	56 (asthmatic children) and 40 (healthy controls)
Mashhad	K. Moradzadeh (17)	2001	Healthy Adults (5,329)	Male and Female	42	35.4
	Z. Rahnavard (18)	2004-2005	Healthy Men (386)	Male	47	48
Shiraz	K. Moradzadeh (17)	2001	Healthy Adults (5,329)	Male and Female	47	56.2
	S. Masoompour (20)	2001	Men (520)	Male	45	33.9
	Z. Rahnavard (18)	2004-2005	Healthy Men (420)	Male	37	46
	S. Faghih (21)	2011-2012	University Students (254)	Male and Female	23	44 (female) and 48 (male)
Tabriz	Z. Rahnavard (18)	2004-2005	Healthy Men (600)	Male	43	63
	N. Aghamohammzadeh	2008-2009	Institutionalized Elderly (140) and Community-	Male and Female	66	75 (institutionalized elderly) and 20.1

	(7)		dwelling Elderly (140)			(community-dwelling elderly)
Tehran	M. Bassir (23)	1996-1997	Mothers and their Neonates (50)	Female	28	80
	K. Moradzadeh (17)	2001	Healthy Adults (5,329)	Male and Female	47	64.9
	S. Hashemipour (24)	2001-2002	Healthy Men and Women (1,210)	Male and Female	40	67.1
	Z. Rahnavard (18)	2004-2005	Healthy Men (469)	Male	43	63
	A. Rabbani (25)	2006	Healthy Children (963)	Male and Female	12	53.6 (girls) and 11.3 (boys)
	F. Hosseinpanah (26)	2006	Healthy Housewives (200)	Female	39	63
	M. Razzaghy-Azar (27)	2006-2007	Healthy Children and Adolescents (313)	Male and Female	13	52
	T. Neyestani (28)	2007-2008	Children (1,111)	Male and Female	10	63.9
	S. Alipour (29)	2011-2012	Women (538)	Female	43	69
	M. Tohidi (30)	2013	Participants (761)	Male and Female	50	34.3
Arak	A. Talaei (4)	2008-2009	School Students (420)	Male and Female	12	84
Zanjan	A. Kazemi (31)	2004-2005	Pregnant Women (67)	Female	28	86.5 (winter) 45.9 (summer)
Bojnurd	H. Shakeri (32)	2010-2011	Children and Adolescents (367)	Male and Female	13	16.1
Shahrood	M. Ebrahimi (33)	2010-2011	School Students (1,047)	Male and Female	14	61.2
Zahedan	M. Kaykhaei (34)	2007-2008	Apparently Healthy Adults (993)	Male and Female	37	85.2
Sabzevar	S. Arbabi Bidgol (35)	2010-2012	Premenopausal Breast Cancer Patients (60)		36	95
Ahvaz	K. Mahdavi (36)	2011-2012	Patients with acute coronary Syndrome (216)	Male and Female	61	48.2
Qazvin	F. Hosseinpanah (26)	2007	Housewives (200)	Female	39	63
Babol	B. Heidar(37)	2008-2011	Patients with Unexplained Arthralgia (453)	Male and Female	38	51.4
	B. Heidar (38)	2010-2012	Females Aged More than 15 Years (696)	Female	45	70.1
Rafsanjan	Z. Jamali (39)	2008-2009	Healthy Students (250)	Female	14	59.6
Gorgan	S. Mohammdian et al. (39)	2012-2013	Children (215)	Male and Female	5	85.6
Sari	Z. Kashi (40)	2009-2010	Women (351)	Female	37	87.5 (winter) 78.6 (summer)

Findings on Environmental Parameters

Table 3 shows the findings of the current research regarding the environmental parameters affecting the light transmission of UV rays through the atmosphere as presented by the geographic databases. Due to the high levels of the environmental parameters, only the data obtained in Tabriz city have been presented.

Table 3. Environmental Parameters (Tabriz, Iran)

Station (Tabriz)			Latitude (38 5 N)			Longitude (46 17 E)				Elevation (1361.0 M)			
Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual
Number of Days with Dust													
2004	2	0	3	3	3	2	0	0	2	2	0	0	18
2005	0	0	3	2	2	5	3	0	3	3	0	0	20
2008	0	2	6	7	10	5	5	1	2	2	0	2	51
2009	0	2	7	8	11	6	19	9	3	3	0	0	70
Number of Days with Visibility of ≥2 km													
2004	8	4	2	2	3	0	0	0	1	1	4	8	32
2005	12	2	4	2	0	0	0	1	0	1	4	3	29
2008	7	9	1	1	3	1	0	0	3	1	1	0	27
2009	4	2	9	5	4	1	1	1	2	1	4	2	36
Total Monthly and Annual Sunshine Hours													
2004	151.0	165.3	209.7	224.2	262.5	360.2	343.0	358.7	319.7	260.7	142.3	187.4	2984.7
2005	113.1	159.1	200.2	225.8	263.1	344.8	356.1	356.6	311.3	260.2	164.7	198.4	2953.4
2008	179.3	154.4	223.8	231.1	263.5	331.8	345.6	312.2	250.4	217.0	194.8	179.3	2878.8
2009	162.6	152.2	152.5	186.8	251.6	237.5	306.6	300.1	254.7	264.6	170.2	127.1	2566.5
Mean Relative Humidity (%)													
2004	74	65	48	53	58	38	42	34	35	42	72	70	53
2005	74	67	52	52	50	39	34	38	39	41	59	61	51
2008	63	67	47	38	40	37	36	28	43	58	65	60	49
2009	67	58	55	55	38	41	35	38	47	42	68	71	51
Mean Daily Temperature (°C)													
2004	2.4	3.1	8.9	10.9	16.5	23.4	25.3	27.4	22.2	16.6	7.6	-2.0	13.5
2005	-2.3	-0.6	7.3	13.4	17.4	22.8	28.0	27.0	22.3	15.7	7.7	5.2	13.6
2008	-5.7	-0.8	10.7	15.7	17.3	23.3	27.2	27.9	22.2	15.0	7.4	1.9	13.5
2009	-0.8	4.8	7.1	10.3	18.2	22.1	26.7	25.0	19.9	15.8	7.9	4.4	13.5
Number of Clear Days													
2004	7	4	8	11	9	25	23	29	28	19	8	10	181
2005	8	8	8	5	9	24	26	28	26	15	9	16	182
2008	15	8	7	5	10	24	25	21	16	13	12	18	174
2009	14	6	6	7	18	11	30	29	17	22	13	6	179
Number of Partly Cloudy Days													
2004	11	17	15	8	14	5	7	2	2	9	12	17	119
2005	6	10	12	17	14	5	5	3	3	16	15	11	117
2008	6	11	20	19	17	5	6	10	13	13	15	5	140
2009	9	17	14	16	11	14	1	2	10	8	11	13	126
Number of Cloudy Days													
2004	13	8	8	11	8	0	1	0	0	3	10	4	66
2005	17	10	11	8	8	1	0	0	1	0	6	4	66
2008	10	10	4	6	4	1	0	0	1	5	3	8	52
2009	8	5	11	7	2	5	0	0	3	0	6	12	60

Analysis Results

The statistical analysis showed a significant correlation between the prevalence of vitamin D deficiency and environmental factors such as cloudy and clear days. In other words, there was a direct correlation between the number of cloudy days and prevalence of vitamin D deficiency ($P=0.037$; $r=0.631$). Moreover, an inverse correlation was observed between clear days and the prevalence of vitamin D deficiency ($P=0.025$; $r=-0.666$). However, no significant association was denoted between vitamin D deficiency and other environmental factors, such as geographical parameters (sunshine, longitude, latitude, elevation, humidity, and temperature) and air pollution parameters (number of days with dust and days with visibility of ≥2 km) (Table 4).

Table 4. Correlations between Vitamin D Deficiency and Environmental Factors

variables	P-value	R	95% CI
Clear Days*	0.025	-0.666	-0.926--0.072
Cloudy and Partly Cloudy Days*	0.037	0.631	-0.068-0.927
Sunshine (hour)	0.233	-0.392	-0.801-0.209
Latitude	0.284	0.355	-0.505-0.843
Longitude	0.600	0.178	-0.517-0.726
Elevation	0.188	0.429	-0.875-0.844
Humidity	0.179	-0.437	-0.905-0.374
Mean Annual Temperature	0.469	-0.244	-0.812-0.659
Dusty Days	0.419	0.272	-0.763-0.806
Visibility of Less Than 2 km	0.160	0.454	-0.474-0.963

*$P<0.05$

Discussion

This is the first study which was conducted on the relationship between environmental factors and prevalence of vitamin D deficiency in the Iranian population. Our findings indicated that the increased number of cloudy days is associated with the higher prevalence of vitamin D deficiency and vice versa (Table 3). Although similar studies are limited in this regard, they have confirmed effects of environmental parameters on the prevalence of vitamin D deficiency.

In a study in France, Baïz et al. (2012) reported that environmental factors, especially exposure to air pollution, are particularly associated with low levels of 25(OH) D in blood samples after pregnancy (10). The results of another study in this regard showed that the prevalence of vitamin D deficiency in children was due to the decreased amount of sunlight transmission to the earth due to environmental parameters, such as cloudy weather and air pollution (Agarwal et al., 2002) (11).

According to the findings of Kashi et al. (2011), the prevalence of vitamin D deficiency was higher in winter and autumn compared to summer, which is probably due to the cloudiness and shortened length of days (40). Another research indicated a direct correlation between non-exposure to sunlight and low levels of 25(OH) D, which could be due to the lack of sunlight due to geographical and air pollution parameters or the fear of exposure to sunlight (1).

The results of the present study showed no significant association between the prevalence of vitamin D deficiency and several air pollution parameters, including the number of the days with dust and days with the visibility of less than or equal to two kilometers (Table 3). However, the results of another study in this regard indicated an independent, inverse correlation between the levels of 25(OH) D and air quality index among children in Isfahan (Iran) (Kelishadi et al., 2014) (9).

In this regard, Hosseinpanah et al. (2007) evaluated housewives in Tehran and Qazvin (Iran), reporting that women living in the areas with air pollution (e.g., Tehran) had lower 25(OH) D levels in their blood samples (26). Furthermore, the special dress code of Iranian women (hijab), which covers most parts of the body, could be an underlying factor for the high prevalence of vitamin D deficiency in Iran.

Conclusion

According to the results, there were significant associations between the prevalence of vitamin D deficiency and environmental factors, such as cloudy and clear days. Therefore, adequate exposure to sunlight for the absorption of vitamin D is strongly recommended. However, no significant correlation was observed between the prevalence of vitamin D deficiency and other environmental factors, such as geographical parameters and air pollution.

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